DATA QUALITY SUMMARY REPORT FOR BETA ATTENUATION MONITOR $PM_{2.5}$ MASS DATA COLLECTED BY SONOMA TECHNOLOGY, INC., DURING THE CALIFORNIA REGIONAL $PM_{10}/PM_{2.5}$ AIR QUALITY STUDY

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1. INTRODUCTION AND OBJECTIVES

The purpose of this Data Quality Summary Report is to provide data users with an understanding of the quality of Beta Attenuation Monitor (BAM $PM_{2.5}$ mass) data collected by Sonoma Technology, Inc. (STI) for the California Regional PM_{10}/$PM_{2.5}$ Air Quality Study (CRPAQS). **Table H-1** summarizes the operating sites and times for BAM $PM_{2.5}$ mass concentration measurements during CRPAQS. This report provides summary information on data completeness, lower quantifiable limit (LQL), accuracy, and precision. BAM $PM_{2.5}$ mass concentrations were measured with 60-minute time resolution. Data completeness was calculated for all sites based on data delivered to California Air Resources Board (ARB); the start date/time indicates the beginning of valid data, continuous until the stop date/time. Data validation suggested that all BAM $PM_{2.5}$ mass instruments performed similarly. Data collected at Angiola (in standard temperature and pressure [STP] units) and at San Jose (actual conditions) were used as representative sites to calculate LQL, accuracy, and precision for all BAM $PM_{2.5}$ mass monitors operated by STI in the study.

As Table H-1 indicates, valid BAM $PM_{2.5}$ mass data from the Angiola Trailer started on January 20, 2000; however, this instrument began operation at Angiola in December 1999. The data reported from December until January 20, 2000, were not of sufficient quality to deliver to ARB. For more information, please reference the quality control screening procedures documented by Hafner et al. (2003).

Table H-1. Location and duration of BAM $PM_{2.5}$ mass measurements performed by STI during CRPAQS.

Site	Actual or STP	Start Date/Time	Stop Date/Time
Altamont	STP	1/28/00 18:00 PST	2/8/01 8:00 PST
Angiola Trailer	STP	1/20/00 7:00 PST	2/6/01 8:00 PST
Bakersfield	STP	1/21/00 23:00 PST	2/6/01 14:00 PST
Bethel Island	STP	11/17/00 13:00 PST	2/15/01 3:00 PST
Corcoran	STP	9/13/00 14:00 PST	11/14/00 21:00 PST
Edwards	STP	6/20/00 19:00 PST	9/1/00 6:00 PST
Sacramento Del Paso	Actual	4/13/00 15:00 PST	2/7/01 7:00 PST
San Jose	Actual	5/18/00 18:00 PST	2/15/01 21:00 PST
Sierra Nevada Foothills	STP	11/19/00 13:00 PST	2/12/01 11:00 PST

Several other documents are available from which to obtain information about the CRPAQS field study and data processing. Sampling locations are described in Wittig et al. (2003). Quality control screening procedures are summarized by Hafner et al. (2003). Results of systems and performance audits and intercomparisons are provided by Bush et al. (2001).

The data quality objectives (DQOs) for BAM $PM_{2.5}$ mass from NARSTO documentation are shown in **Table H-2**. These DQOs were originally set for BAM PM_{10} mass. DQOs for BAM $PM_{2.5}$ mass were not available. The BAM $PM_{2.5}$ mass data meet the NARSTO DQOs for LQL, accuracy, and precision. No DQO was available for data completeness.

Table H-2. Data quality objectives for BAM $PM_{2.5}$ mass data collected during CRPAQS.

Data Quality Metric	NARSTO Objective
Lower Quantifiable Limit	5 $\mu g/m^3$
Accuracy	3%
Precision at < 80 $\mu g/m^3$	5 $\mu g/m^3$
Precision at < 80 $\mu g/m^3$	7%

2. DATA COMPLETENESS

Data completeness for 60-minute BAM $PM_{2.5}$ mass sites is shown in **Table H-3**. Data capture quantifies the percentage of total records received versus the number expected during the "period of operation" defined by the start and stop dates/times in Table H-1; the start date/time is the first instance of valid data, and the period of operation is continuous until the stop date/time. The number of valid data points is divided by the number of captured data points to calculate the data recovery. Validity is defined for this calculation as any data point that has a quality control flag of V0 (valid) or V1 (valid but comprised wholly or partially of below-MDL data). Details of data validation are included in Hafner et al. (2003).

Table H-3. Data completeness values for BAM $PM_{2.5}$ mass (60-minute) at each site.

Monitoring Site	Total No. of Records	No. of Expected Records	Percent Capture[a]	No. of Valid Records	Percent Recovery[b]	No. of Suspect Records	No. of Invalid Records	No. of Missing Records
Altamont	9039	9039	100%	6579	73%	623	1102	735
Angiola Trailer	9194	9194	100%	7566	82%	1254	161	213
Bakersfield	9159	9160	100%	8298	91%	744	93	24
Bethel Island	2151	2151	100%	1536	71%	491	77	47
Corcoran	1496	1496	100%	1285	86%	37	55	119
Edwards	1740	1740	100%	1617	93%	108	9	6
Sacramento Del Paso	7193	7193	100%	2750	38%	3428	405	610
San Jose	6556	6556	100%	5473	83%	777	144	162
Sierra Nevada Foothills	2039	2039	100%	1859	91%	86	25	69

[a] % of capture = total number of records/expected records*100%
[b] % recovery = number of valid records/total number of records

All sites had a 100% data capture rate. Data recovery rate (% valid) ranged from 38% (Sacramento Del Paso) to 93% (Edwards) which exceeds the CRPAQS DQO. The Sacramento BAM $PM_{2.5}$ mass instrument experienced numerous power failures in May and June 2000 (resulting in missing data) and some tape transport errors in June, October, and December 2000 (resulting in invalid data). The flow rates did not meet specifications due to a temperature probe problem from July 14 through December 8, 2000; volume, and concentration data were flagged as suspect

3. LOWER QUANTIFIABLE LIMIT

The LQL is the lowest concentration in ambient air that can be measured when processing actual samples. Sources of variability that influence the monitored signal at low concentrations include instrument noise and atmospheric variability. As a measure of this variability, two times the standard deviation of selected 60-minute data was used to estimate the LQL. The selected data were collected during relatively stable periods with concentrations close to zero. This is a conservative estimate of the LQL because it includes the concentration variability of the ambient air. Six data points were used with the 60-minute data because atmospheric variation generally becomes too great after six hours to calculate a reasonable LQL.

The LQL is calculated as shown in Equation H-1. **Table H-4** shows the LQL, as well as the specific data strings used to calculate the LQL. The LQLs meet the DQOs.

$$\mathrm{LQL} \approx 2s = 2\sqrt{\frac{\sum (BAM - \overline{BAM})^2}{N-1}} \qquad \textbf{(H-1)}$$

where:

$\overline{BAM}$ = mean BAM $PM_{2.5}$ mass concentration
N = number of measurements
σ = standard deviation

Table H-4. Time period used to calculate LQL, the LQL, and the corresponding mean concentration during the selected time period at representatives sites, Angiola (STP) and San Jose (actual).

Site	Time Period Used in LQL Calculation	LQL (μg/m^3)	Mean (μg/m^3)
Angiola Trailer	4/16/00 05:00 – 11:00 PST	1.8 (STP)	1.0 (STP)
San Jose	11/14/00 14:00 – 20:00 PST	1.5 (Actual)	1.2 (Actual)

4. ACCURACY

Calibration data for the BAM is not available since the BAM cannot be calibrated in a manner similar to instruments measuring gaseous species. Validation flow checks were performed periodically on the BAM $PM_{2.5}$ mass; these checks can be used to evaluate the accuracy of the flow through the instrument throughout the study. This technique quantifies the variability of the measured flow from the periodic flow checks. While not the true accuracy of the $PM_{2.5}$ concentration measured by the BAM, if most of the error is assumed to be due to flow changes, this method provides a sufficient surrogate.

Accuracy can be expressed in terms of the 95% confidence interval (CI). For BAM $PM_{2.5}$ mass measurements, the 95% CIs were calculated from the differences between the monitor's measured flow and the known flow provided by the flow checks. The 95% CI approximates the accuracy of the data as shown in Equation H-2.

$$\text{Accuracy} \approx 95\%\ \text{confidence interval} = \frac{1.96\left(\frac{s_{flowcheck}}{\sqrt{N}}\right)}{\left[\overline{BAM}\right]_{flowcheck}} \times 100\% \qquad \textbf{(H-2)}$$

where:

$$s_{flowcheck} = \sqrt{\frac{\sum (x - \bar{x})^2}{N - 1}}$$

$$\text{x} = [\text{BAM}]_{\text{flowcheckl}} - [\text{BAM}]_{\text{measured}}$$

$$\bar{\text{x}} = \frac{\sum ([\text{BAM}]_{\text{flowcheck}} - [\text{BAM}]_{\text{measured}})}{\text{N}}$$

$[BAM]_{flowcheck}$ = BAM $PM_{2.5}$ mass true flow as per flow check.

$[\text{BAM}]_{\text{measured}}$ = flow measured during flow check by the BAM $PM_{2.5}$ mass

Periodic flow checks were performed at all sites; Angiola (STP) and San Jose (Actual) are used as the representative site for all BAM $PM_{2.5}$ mass monitors operated by STI during CRAPQS. The average flow measured during flow checks, $[\overline{\text{BAM}}]_{\text{measured}}$, was calculated by averaging the measured flows during the periodic flow checks. The 95% CIs and the number of flow checks used to estimate the CIs for BAM $PM_{2.5}$ mass at Angiola and San Jose are provided in **Table H-5**. The accuracy computed using flow check data meets the DQO.

Table H-5. Accuracy and number of flow check data points used for the BAM $PM_{2.5}$ mass concentrations at the representative sites, Angiola and San Jose

Site	No. of Flow Checks Used	Accuracy
Angiola Trailer	26	1.7%
San Jose	25	2.5%

5. PRECISION

Precision can be measured for the BAM $PM_{2.5}$ mass by evaluating the variance of $PM_{2.5}$ concentrations during a period of low variability, when atmospheric influence on variability is assumed to be minimal. Data collected during periods of low variability, but when concentrations were well above the LQL, were selected. The precision was then evaluated by calculating the coefficient of variation (CV) during the period of low variability, as shown in Equation H-3.

$$\text{Precision} \approx \text{CV} = \frac{\sigma_{\text{measured}}}{\left[\overline{\text{BAM}}\right]_{\text{measured}}} \times 100\% \qquad \textbf{(H-3)}$$

where:

$$\sigma_{\text{measured}} = \sqrt{\frac{\sum\left([\text{BAM}]_{\text{measured}} - \left[\overline{\text{BAM}}\right]_{\text{measured}}\right)^2}{N-1}}$$

All the BAM $PM_{2.5}$ mass concentrations in Equation H-3 refer to the concentrations measured during the selected time period. **Table H-6** shows the precision calculated for the representative sites Angiola (STP) and San Jose (Actual). The precision of the BAM $PM_{2.5}$ mass measurements meet the DQO at the mean concentrations noted.

Table H-6. Precision, the number of data points, time period, and mean of the data used to calculate the precision of the BAM $PM_{2.5}$ data at the representative sites, Angiola and San Jose.

Site	No. of Data Points Used	Time Period	Mean (µg/m^3)	Precision
Angiola	7	11/22/00 17:00 – 11/23/00 00:00 PST	31.3 (STP)	7.1%
San Jose	6	9/25/00 18:00 – 9/26/00 00:00 PST	18.0 (Actual)	6.1%

6. REFERENCES

Bush D., Baxter R., and Yoho D. (2002) Final quality assurance audit report - California Regional $PM_{2.5}$/PM_{10} Air Quality Study (CRPAQS). Prepared for San Joaquin Valleywide Air Pollution Study Agency c/o California Air Resources Board, Sacramento, CA, by Parsons Engineering Science, Inc., Pasadena, CA, June.

Hafner H.R., Hyslop N.P., and Green C.N. (2003) California Regional $PM_{10}/PM_{2.5}$ Air Quality Study management of anchor site data. Prepared for the San Joaquin Valleywide Air Pollution Study Agency c/o California Air Resources Board, Sacramento, CA, by Sonoma Technology, Inc., Petaluma, CA, 999242-2087-FR (scheduled for publication May 2003).

Watson J.G., DuBois D.W., DeMandel R., Kaduwela A., Magliano K., McDade C., Mueller P.K., Ranzieri A., Roth P.M., and Tanrikulu S. (1998) Aerometric monitoring program plan for the California Regional $PM_{2.5}/PM_{10}$ Air Quality Study. Draft report prepared for the California Regional $PM_{10}/PM_{2.5}$ Air Quality Study Technical Committee, California Air Resources Board, Sacramento, CA, by Desert Research Institute, Reno, NV, DRI Document No. 9801.1D5, December.

Wittig A.E., Blumenthal D.L., Roberts P.T., and Hyslop N.P. (2003) California Regional $PM_{10}/PM_{2.5}$ Air Quality Study anchor site measurements and operations. Final report prepared for the San Joaquin Valleywide Air Pollution Study Agency c/o California Air Resources Board, Sacramento, CA, Sonoma Technology, Inc., Petaluma, CA, STI-999231-2332-FR (scheduled for publication May 2003).